

Domination of Commercial Patents in the Evolution of Early Reinforced Concrete: Case-Study of the Region of Brussels

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Abstract The advent and early developments of reinforced concrete were related to national patenting. This paper proposes an in-depth study of the logic of reinforced concrete patents at the turn of the 20th century, based on the case of Belgium. Before the First World War, a considerable number of systems were patented by private inventors for commercial purposes. Patents on reinforced concrete constitute today a primary source of information, both for their technical content and for the assessment of the market penetration of the innovative material. The scientific reliability of these patents is variable and ranges from the rational to the unrealistic. Propagation of reinforced concrete occurred following international trends, such as Hennebique or Monier, or by local inventors, mainly building contractors. Reinforced concrete started to be considered as a structural material after the French engineering standard of 1906, adopted by Belgium. Moreover, examining these patents helps to understand the structural specificities of the early phase of reinforced concrete. Therefore, this study enhances the conservation process of such construction.

Keywords: Early reinforced concrete, patent, conservation, construction prior to 1914

Introduction

The period 1880-1914 constitutes a turning point between reinforced concrete considered as a system progressively defined by commercial patents and as a new material, leading to specific rules, standards and broad applications (Delhumeau 1999). Before the First World War, various systems of reinforced concrete were patented as inventions country by country, which led to a competitive business between holders of patents in Belgium and in other European countries. The era of patents was definitely the starting point of a new material and process of construction (Bussell 2001).

So far, few studies have been dedicated to the specificities of engineering patents on reinforced concrete. However, the understanding of the system of patents on the eve of the 20th century is essential to approach the inventions and implementations of reinforced concrete in its true perspective. Therefore, the first need is to identify the protagonists of the diffusion of the material in Belgium. Secondly, their contributions through patents, literature or pieces of work contain essential technical information, useful for any appraisal of a reinforced concrete structure prior to 1914. Assessing such structures requires knowledge about their structural characteristics. Finally, the increase of patent submissions on reinforced concrete shows that the new material was at the centre of the attention of the industry at the turn of the 20th century. This trend may also reflect also the economic impact of the composite material in the field of construction.

Patents in the Legal System of Belgium

Briefly speaking, a patent, defined by national law, is today a title which ensures to its holder the exclusive monopoly to take profit from it. The basic positive effects are, firstly stimulating research and invention, secondly diffusing innovation and thirdly protecting inventors and firms. According to Schumpeter, an invention is synonym of "creation of novelty" and innovation is "the transfer of the novelty from concept to industrial and commercial stages". Therefore, patents are at the

intersection between the invention that they commercialized and the innovation that they stimulate (Peters 2006). However, this point of view is somehow simplified because many inventions contain initially economic backgrounds (Galvez-Behar 2008).

The Belgian law legalising patents until the end of the First World War was published in the official journal *Moniteur Belge* in 1854 (Fig. 1). A patent, submitted to the Ministry of Industry and Labour (namely now *Office Belge de la Propriété Intellectuelle*, OPRI), was accepted without any verification of its relevance, originality or feasibility (Fig. 1). Therefore, the quality of patents is rather unequal. The process was similar in France for instance whilst in German or American legal systems, strict reading was made by competent authorities (Inkster 2005). Moreover, submitting a patent did not prove its actual use in practice. However, patents are considered as a qualitative tool to estimate the inventive activity of countries (Griliches 1990) but setting back in their historic and economic national context.

LE MONITEUR BELGE,

JOURNAL OFFICIEL.

24^e ANNÉE. JEUDI, 25 MAI 1854. N° 145

MINISTÈRE DE L'INTÉRIEUR.

LOI sur les brevets d'invention.

LÉOPOLD, Roi des Belges,

A tous présents et à venir, SALUT.

Les Chambres ont adopté et Nous sanctionnons ce qui suit :

Art. 1^{er}. Il sera accordé des droits exclusifs et temporaires, sous le nom de brevet d'invention, de perfectionnement ou d'importation, pour toute découverte ou tout perfectionnement susceptible d'être exploité comme objet d'industrie ou de commerce.

Art. 2. La concession des brevets se fera sans examen préalable, aux risques et périls des demandeurs, sans garantie, soit de la réalité, soit de la nouveauté ou du mérite de l'invention, soit de l'exactitude de la description, et sans préjudice des droits des tiers.

Figure 1: The Belgian law of May 21st 1854 on patent (OPRI 1854)

As shown in Fig. 2, the number of submissions of patents in Belgium increased from around 3000 in 1880 to 11000 before the outbreak of the First World War (Peters 2006). During the 19th century until the mid of the 20th century, Belgium participated also to industrial and international exhibitions and even organised several of them in Brussels, Liège, Ghent and Antwerp from 1885 to 1958. These popular events allowed a wide transmission of new industrial developments.

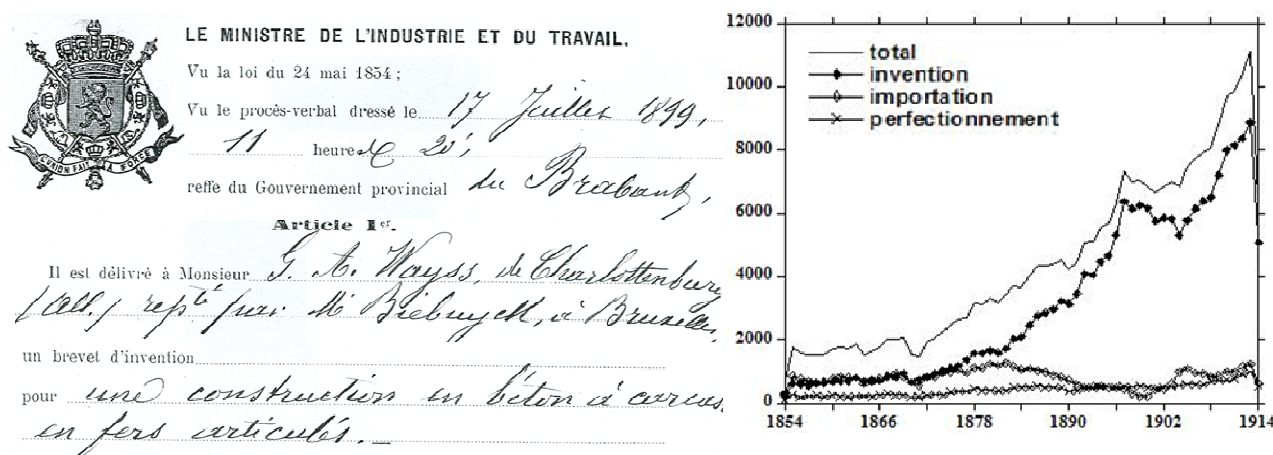


Figure 2: Left: front page of a patent of invention granted to G.A. Wayss in 1899 (OPRI); Right: evolution of the submission of patents in Belgium until 1914 (Peters 2006)

Specificities of reinforced concrete patents in Belgium: what, who, when, why, how many?

At that time, a so-called reinforced concrete system is defined as a particular combination and disposition of elements (steels bars and concrete) to be applied for a specific purpose (slabs, columns, etc.). Patents specify usually the function of the reinforced concrete elements as slabs,

beams, columns, etc. Moreover, they describe the location and the type of reinforcements (bottom flange, curved bars, etc.) and sometimes also the reasons for such arrangement (against tension, shear force, etc.). In this regard, Colby defines "a system of reinforced concrete" as "a distinctly special feature in connection with this method of construction" (Colby 1909). The reinforcement made of iron or steel bars, round or flat, was positioned following a particular commercial system, patented by companies or individuals. Concrete matrix followed usually a given composition according to the final function of the element. Most of the reinforced concrete patents were submitted by commercial agencies, acting as intermediary body between inventors and the diffusion of their invention (Galvez-Behar 2008). However, many patents focused on the technologies of rebars and brought little improvements to the technique or to the technology. More and more similar so-called novelties were submitted through time. The content of the patents varied from precise and specific details to global and more conceptual approach. As for many other topics, "patents differ greatly in their technical significance. Many of them reflect minor improvements of little economic value. Some of them, however, prove extremely valuable. Unfortunately, we rarely know which are which and do not have yet a good procedure for "weighting" them appropriately" (Griliches 1990).

The patents submitted in Belgium during the 19th century are classified by year and fall all into a single category. The first occurrence of the subcategory *Constructions in reinforced concrete*, in the global category *Civil engineering*, dates from 1898. The consultation of the archives of the OPRI offers more than 230 inventions on the topic of reinforced concrete submitted between 1886 and 1913. The number of patents related to this topic soared after 1899-1900. This estimation of 230 patents is certainly conservative, because the review took into account only the patents which mention explicitly the combination of steel and concrete in their description and no other outputs. Furthermore, some inventions were perhaps even not patented. The case of the contractor A. Blaton (1835-1905) is surprising but representative, since he was one of the first who build in reinforced concrete in Belgium but without patenting anything in civil engineering.

"Reinforced floor constructions have reached such a diversity that the number of systems cannot be listed; there are almost 300 of them and nearly every week has one more, which in most cases does not represent any improvement" noticed soon the German E. Mörsch in 1903 (Kurrer 2008). Comparing to France, Belgium received an impressive submission of patents. This may be explained by the fact that the legal access to patent was very liberal, that the country was open to the importation of foreign inventions and by the economical importance of Belgium at that time.

At the beginning of the 20th century, technical ideas are spread mainly by independent persons. A well prepared and organised innovative activity, by laboratory researches, institutional research groups or international companies, such as we know today, did not (Galvez-Behar 2008). The patents on reinforced concrete in the early stage were generally submitted by building contractors and seldom by engineers or architects: "While engineers were doubting and scientists were calculating, inventors applied and improved, and practice bring every day of new facts" (Christophe 1899). Firstly, they identified and anticipated the constructive values of reinforced concrete. Secondly, they dare to believe on its potential. Moreover, many entrepreneurs had both technical skills and commercial notions.

Catalogue of Common Early Systems Used in Brussels

Reinforced concrete innovations are reported in numerous general and specialized journals. The Belgian journals reporting on the application of reinforced concrete were issued by administrations (e.g., *Les Annales des Travaux Publics de Belgique*), professional bodies (e.g. the architectural magazine *L'Emulation*), universities (e.g. the periodical *Revue Universelle des Mines*), private companies (e.g., *Le Béton Armé*, journal of Hennebique published from 1898 to 1939) or even private editors. Around 1900 and during the following decades, engineers – mainly - published technical manuals, such as Christophe (1902), Maurel and De Tedesco (1904), Mörsch (1906), Cosyn (1911). Through this literature in French, but also through advertisements (Fig. 3), Belgian contractors, architects and engineers were aware of several reinforced concrete systems. Nevertheless, many other systems, less known, were also submitted as patents.



Figure 3: Advertisements of Coignet and Siegwart mentioning explicitly the patent taken about ferro-concrete (Archives d'Architecture Moderne, Brussels)

Several famous foreign systems (mainly from the UK, Germany, France, the USA) were patented in Belgium, as Monier, Hennebique, Coignet, Matrai, Luitpold, Lefort, Klett, Cottancin, Khan, Boussiron, Mesnager, Ransome, Wayss, to name only a few but essential inventors in the history of the development of reinforced concrete. According to the inventory of the early reinforced concrete constructions in Brussels (Hellebois 2009), Hennebique, Herbst and Siegwart are, for instance, foreign systems which were successfully implemented in Brussels. Besides having started his career in Belgium, F. Hennebique (1842-1921) was absolutely dominant in Brussels, with more than 80 % of the market of reinforced concrete. This achievement is incidentally due to a particular attention to the design of reinforced concrete with high commercial performances to develop his business. A few national systems enjoyed some success, such as Dumas & Perraud, Vasanne, Monnoyer, Frankignoul, etc. The distinction between international and local systems is clear but the practical use of both of them remains blurred.

Table 1 mentions a limited number of patented systems which are important regarding their diffusion but also the practice of reinforced concrete in Brussels at the turn of the 20th century. A comparison based on the arrangement of the reinforcements in concrete is proposed (Fig. 4). The date is an indication of the first patent granted in Belgium to the inventors.

Table 1: Some common reinforced concrete systems used in Brussels (Hellebois, from Bussell 2001)

Name of the system	Form of longitudinal bars located		Form of shear reinforcement
	in tension	in compression	
Monier (Fr., 1886)	Round straight bars	Round straight bars	Round rods – vertical
Hennebique (Fr., 1886)	Round straight bars and round bars bent up near supports	Round straight bars	Steel strip bent up to U-shape – vertical
Coignet (Fr., 1903)	Round straight bars and round bars bent up near supports	Round straight bars	Bent up ends of extra tension bars – Warren like looking truss of wire
Siegwart (Ch., 1900)	Round straight bars	Round straight bars	Round rods - vertical
Perraud & Dumas (Be., 1902)	Round straight bars round bars and bent up near supports	Round straight bars	Steel strip bent up to U-shape – lattice
Vasanne (Be., 1902)	Round straight bars	Round straight bars	Round rods - lattice
Monnoyer (Be., 1908)	Round straight bars	Round straight bars	Steel strip bent up to U-shape – lattice
Frankignoul (Be., 1909)	Round straight bars	Round straight bars	Round rods

The systems Monier and Coignet were consisted of round bars located in tension and compression area, linked together by steel wires. The Monier system, developed and commercialized by Wayss & Freitag, among others, was very popular in Germany, Austria and western Europe. It was a considerable competitor of Hennebique. In the system Hennebique (actually improved in 1892), half of the longitudinal round bars are bent up at 1/3 of the span to be in tension above the supports. Hennebique applied for 13 patents in Belgium from 1886 to 1905 (OPRI). Hennebique's patents present principally two main novelties: the flat stirrups to resist shear forces and the systematic link between slab, beam and column, insuring a monolithic construction. Patents form the basis of his commercial organisation. Before the outbreak of the First World War, up to thirty Belgian building contractors (Delvaux, De Waele, Hambresin, François & Fils, etc.) were licensees of Hennebique. The Swiss firm Siegwart specialized in reinforced concrete

prefabricated floor forming a kind of hollow core beam. L. Monnoyer & Fils, patented an assembly of prefabricated elements to create any type of construction with an axis of revolution (chimney, water tower, etc.). They achieved to export their invention abroad (for instance in France). The characteristic of the patent of A. Vasanne is a continuous lattice grid giving a stiff skeleton in the beam and in the slab. However, the transversal bars, composing the grid, do not connect the beam with the slab and consequently do not constitute a monolithic construction, contrary to the system of Hennebique. E. Frankignoul submitted a system of deep foundation. The principle of the system is, in short, to reach good soil thanks to a conic perforation tube driven in with a hard steel tip. When the desired soil layer is reached, the perforation tube is taken out and concrete is poured in. Other deep foundations existed at the same time, on one hand in-situ piles like Simplex type (1903), and on the other hand precast piles as Hennebique (1896), Coignet (1896) or Considère (1908). The company exported swiftly its patent and exploited it everywhere in the world successfully, already before the First World War.

The high diversity of systems proposed in Belgium shows an abundance of ideas and a creative enthusiasm around the new material. Nevertheless, their quality, based on structural or practical or technological criteria is rather unequal. Moreover, many systems were patented but the application and the impact of such submission in the economic reality is vague.

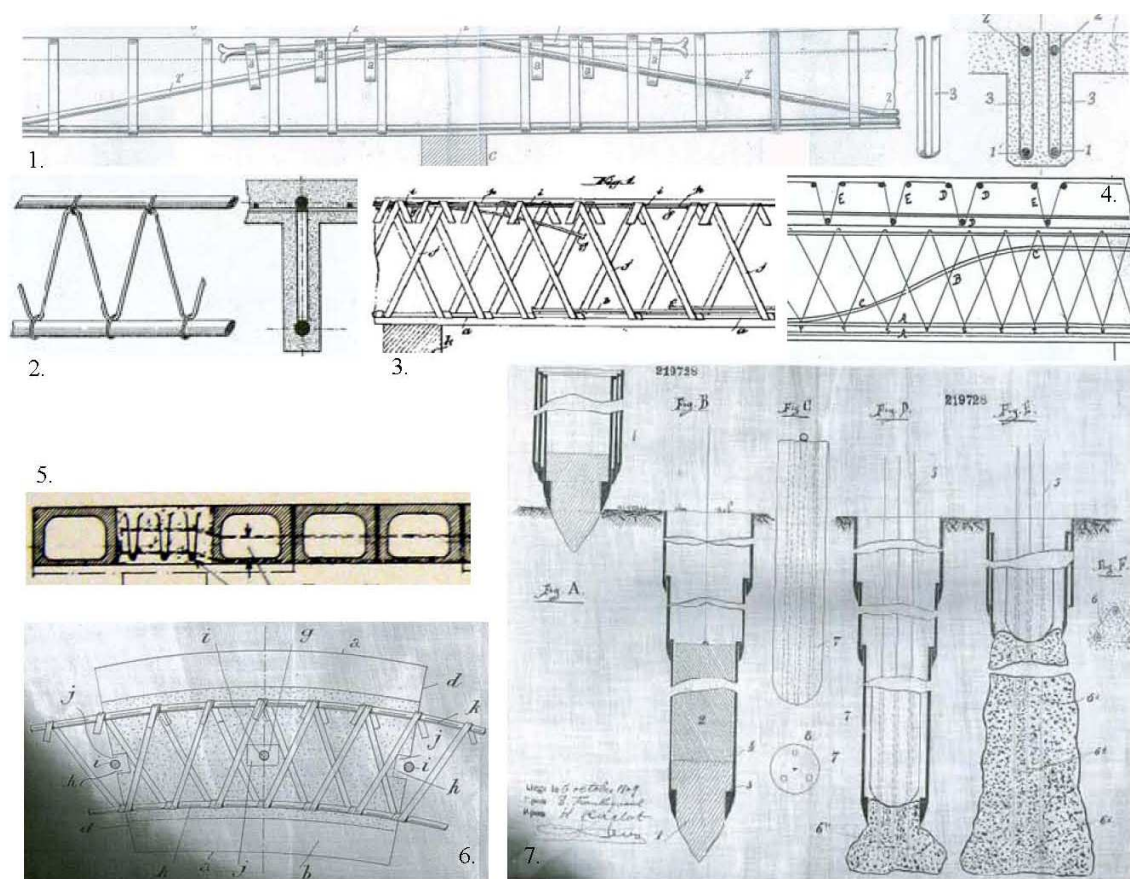


Figure 4: Details of the systems patented in Belgium by the following inventors: 1. Hennebique, 2. Coignet, 3. Perraud & Dumas, 4. Vasanne, 5. Siegwart, 6. Monnoyer, 7. Frankignoul (OPRI)

Conclusion

A better understanding of the material, on both historic and technical points of view, is essential for good conservation, efficient restoration and adapted uses according to contemporary times.

Patents are a genuine source of information still available nowadays. During the end of the 19th century until the start of the 20th century, reinforced concrete patents supported both the development of structural forms adapted to the materials and the innovations in the processes of

construction. However, many inventors kept more or less secret their design methods and components and properties of the used materials. Patents played also a critical role in transmission of reinforced concrete technique in Belgium and elsewhere. This diffusion had two levels, national and even international trends and local individual inventors. Moreover, many media promoted the new materials but encouraging a particular commercial system. The system of patent played also a significant role for reinforced concrete in the industrial implementation of the material. Furthermore, they allow nowadays to discover the existing past network of this invention (involved persons, means, etc.). As for many businesses, the number of delivered patents represents a reliable indicator of the economic reinforced concrete activity at that time. However, the sources of invention (localisation, initial interest), the novelty of the patent, its technical usefulness and effective applicability remain difficult to evaluate. From 1900's and the World Fair of Paris onwards, the tendency has been to develop and codify the design and use of reinforced concrete. Theoretical standards relieved therefore reinforced concrete from proprietary systems.

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